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PLANNING FOR BYPASSES AROUND TOWNS

(First Revision)

INDIAN ROADS CONGRESS

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ABBREVIATIONS AND ACRONYMS

CMP	Comprehensive Mobility Plan
TIA	Traffic Impact Assessment
ANPR	Automatic Number Plate Recognition
GPS	Global Position System
ITS	Intelligent Transport System
API	Application Programming Interface
IRC	Indian Roads Congress
SIA	Social Impact Assessment
NSDP	Net State Domestic Product
PIA	Project Influence Area
EPE	Eastern Peripheral Expressway
ORR	Outer Ring Road
HMA	Hyderabad Metropolitan Area
HMDA	Hyderabad Metropolitan Development Authority
GHMC	Greater Hyderabad Municipal Corporation

PLANNING FOR BYPASSES AROUND TOWNS

1. INTRODUCTION

ne document on bypasses around towns was first published in 1988. Since then there have been lot of development and upgrading of highways in both urban and non-urban areas throughout e country. Traffic has also witnessed a significant growth and also its consequences in rms of pollution, congestion and risk of accidents, therefore. Need has arisen for review of e document.

ccordingly, the task was assigned to Urban Roads and Streets Committee (H-8). The H-8 ommittee constituted a subgroup headed by Shri D.P. Gupta, comprising other members of the ubgroup as Shri S.K. Marwah, Dr. Ch. Ravi Sekhar, Shri G. Sharan, Prof. (Dr.) K.V.K. Rao and rof. Sairam Dasari. The initial draft prepared by the subgroup was discussed and deliberated uring various meetings of the H-8 Committee and it was decided to modify the title to read s "Planning for Bypasses Around Towns". The draft was finalized by the H-8 Committee in its eeting held on 30.04.2022.

he composition of H-8 Committee is given below:

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Secretary General, Indian Roads Congress	(Nirmal, S.K.), Additional Director General-Nodal, Ministry of Road Transport and Highways

The revised draft document was placed before the Highways Specifications and Standard Committee (HSS) in its meeting held on 04.06.2022. The HSS Committee approved this documer subject to suitably incorporating written and verbal comments received and also recommended for placing before the meetings of Executive Committee (EC) and Council. The EC in its meetin held on 16.06.2022 approved the draft document for placing before the Council. The 222nd Mid Term Council in its meeting held on 17th – 18th June, 2022 at Shillong (Meghalaya) considere and approved IRC:102-2022 "Planning for Bypasses around Towns" *(First Revision)* for printing

2. PURPOSE OF A BYPASS

Traffic plying on highway many a time has to pass through towns and cities of various size with or without the purpose of halting within the urban areas. The non-halting traffic is known a through traffic (External Traffic) with its origin and destination lying outside the limits of the urba area. The halting traffic is known as Internal to External and External to Internal traffic, with eithe its origin or destination within the limits of the urban areas.

The proportion of through traffic to total traffic in the case of medium sized towns. (With populatio 5 lakhs to 10 lakhs) and small sized towns (with population below 5 lakhs) will be larger tha that of large cities. In the large cities, the share of external to internal and internal to externa traffic is higher. The frequent interaction of through traffic with the local traffic of the urban are brings down the level of performance of the city network. It also erodes the traffic environmer of the cities. In all such cases, proper planning of an urban bypass assumes great importanc for providing unhindered movement to the through traffic and decongesting the core areas of th city networks.

In most of the cities, once the bypass is provided and is operational the local level activities sta getting developed along the bypass due to increase in accessibility levels. This results in los of the desired functionality of the bypass. To reduce such eventualities taking place along th bypass alignment, the master plan for the city should restrict the local level developments alon the bypass and promote the regional level activities. This will help in maintaining the functionalit of the bypass. Apart from these, the master plan should also restrict direct access to bypass This document also covers guidelines on spacing of intersections on urban bypasses to maintai the desired functionality and efficiency in transport movement. The bypass alignment should b planned according to the city growth limits as per master plan/development plan.

most Indian cities, it is observed that the cities initially planned with a bypass for regional ovement (through traffic) and as the city size increases the regional bypass loses its desired nctionality and starts serving as an urban road and a new regional bypass will need to be anned for regional movement. The old bypass road will act as inner ring and new ring will act s outer ring for through traffic which results in decongestion of core areas (**Fig. 1**).

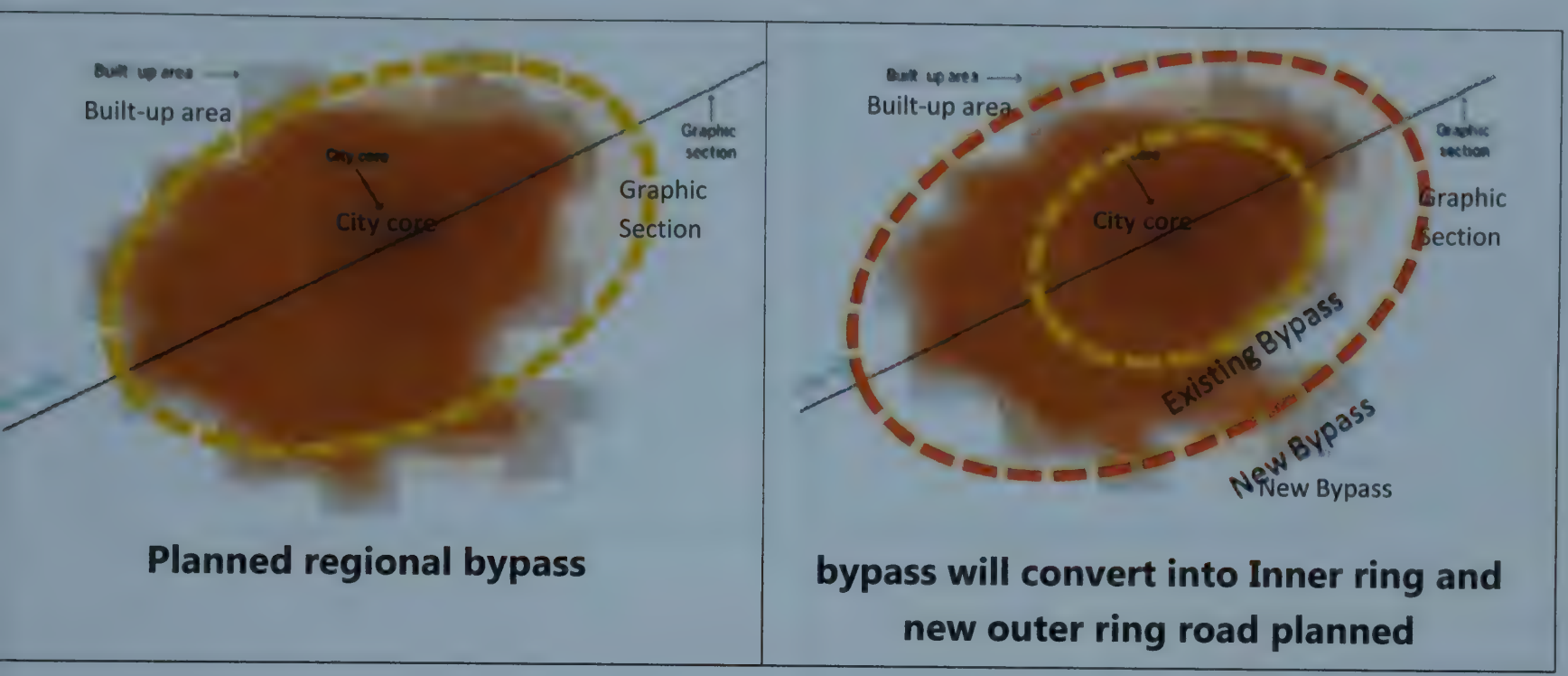


Fig. 1 City Growth and Urban Bypass

3. SCOPE

articulars such as volume, origin, destination, and delays, pertaining to through and local traffic e required for justifying the provision of a bypass. Depending upon its origin and destination, e traffic going through a town can be classified as:

I. External to External (E-E): Traffic whose origin and destination both are outside the town/city

II. External to Internal (E-I): Origin of traffic outside and destination inside the town/city

III. Internal to External (I-E): Origin of traffic inside and destination outside the town/city; and

IV. Internal to Internal (I-I): Traffic whose origin and destination both are within the town/city

xternal to External traffic is usually totally bypassable (through) whereas other traffic is not. A rtion of bypassable traffic may have to enter the town for purposes of refreshments, fuel filling, nor repairs, etc. By providing such facilities along the proposed bypass, the demands of this ffic can be easily met and the traffic successfully diverted. Such details must form an integral rt of planning for any proposed bypass.

addition to above information, frequency and route description of the bypassable traffic is also quired for planning the bypass. This information is collected through comprehensive surveys suitably selected outer cordon points around the town.

This document provides - guidelines on conducting studies on traffic expected for planning urba bypasses as also analysis of the data. Suitable proforma for recording the data and their analys are provided in **Form 1** to **Form 12**. **Fig. 2** below illustrates the travel movement pattern in ar city. This document also considers the access management principles that need to be followe for avoiding dysfunctionality of the bypass.

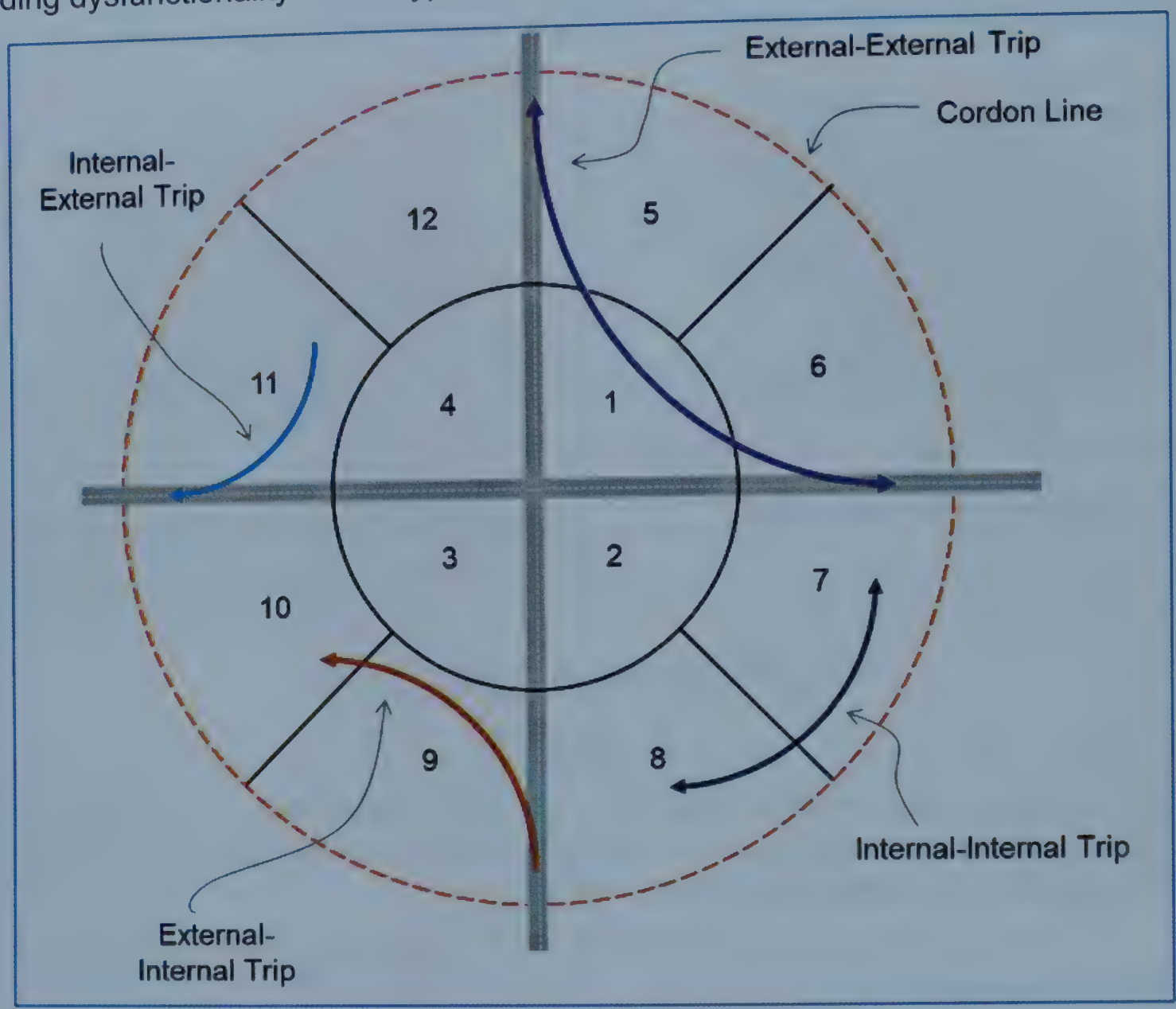


Fig. 2 Travel Movement Pattern

4. CITY SIZE AND TRAVEL MOVEMENT PATTERN

From the published Comprehensive Mobility Plan (CMP) studies in India, it is observed that the city size increases the share of external to external (through) traffic is decreased due to t presence of bypass in those cities. Cities with less than 20 lakh population have almost 20% 30% as external to external traffic movement.

City Size	E-E	I-E & E-I
Population Less than 20 lakhs	20% to 30%	80% to 70%
Population Above 20 lakhs	10 to 15%	90% to 85%

Source: CMP studies in India

Based on various traffic studies (secondary information), it is desirable to go in for an urb bypass if the external to external traffic is more than 15% of total traffic in any urban area.

The other warrants that can be used in decision making could be Level of Service (LOS) improvement in the urban transport network of the city for which the bypass is being planned. Design LOS for roads with in urban transport network is LOS –C (V/C ratio 0.56-0.70). The urban transport network experiencing frequent drop in LOS to D (V/C more 0.70) is an indication to plan by pass for the external through traffic. It is expected such bypasses shall provide a LOS B to the through traffic and also bring in efficiency in the operation of freight and other commercial traffic. This can be an additional warranty for planning a bypass.

5. IMPORTANCE OF EXTERNAL TO INTERNAL AND INTERNAL TO EXTERNAL TRAFFIC

In Indian cities, it is observed that, as the city size increases, the internal to external and external to internal trips increase. In such cases also a bypass is highly desirable where more than 35% of traffic is external to internal or internal to external during the peak hour in the city. Urban bypasses will also help to have directional terminals and logistics facilities where external to internal and internal to external traffic, mainly the trucks and buses can have a halt at outer cordon points and from there smaller vehicles can be used for internal to external or vice a versa within the city. This will eventually reduce the decongestion levels in the core areas.

Most of the Indian cities have radial network pattern, where every major road passes through the core area or connects to core area which results in congestion of core area network with having all travel movement patterns (I-I, I-E, E-I & E-E). In such situations, city bypasses are preferably in the form of ring road systems, but they may also directly traverse urban areas in the form of expressways or elevated roads. The urban bypass will also be often beneficial around cities from the safety, environmental and urban design perspectives.

Fig. 3 below illustrates a case example of benefits by having urban bypass to decongest the core area network of the urban areas.

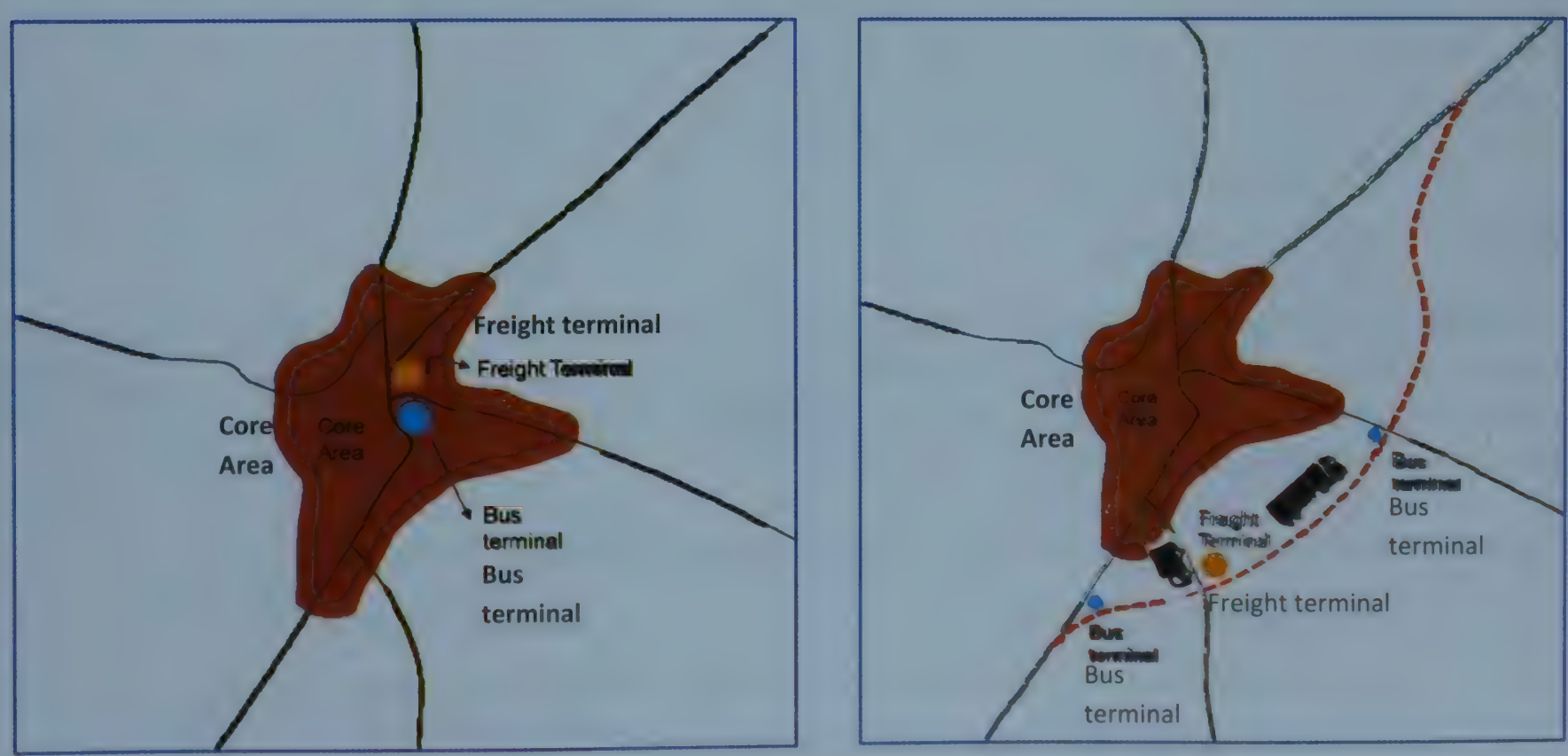


Fig. 3 A Case Example of Urban Bypass

6. PRINCIPLES OF ALIGNMENT AND ACCESS MANAGEMENT

6.1 Broad Principles

The Urban bypass should be carefully planned to reduce or avoid the local level mobility (Internal to Internal) access to the bypass and all along the intersecting roads. Access to the planned bypasses should be provided only through interchanges with major roads (Arterial, or National Highway or state highway). The interchanges will have direct implications for activity growth in those catchment areas and all along the major roads which are leading to the interchange with bypass. Keeping in view of these reasons, while planning the urban bypass, it is essential to identify the appropriate locations for interchanges and entry/exit or site circulation for the development in those areas, as well as between the communities. The limited access on urban bypass helps to maintain the desirable functionality of the bypass. However, only proper land use and street network planning by affected local government will minimize potential urban sprawl and ensure safe and convenient local mobility. Adequate Right of Way (RoW) will be needed for future upgrading including widening, provision of service roads, grade separated intersections and crossing facilities.

6.2 Pedestrian and Slow-Moving Vehicles

Heterogeneous traffic, speeds on urban bypass are prone to risk of accidents to Vulnerable Road Users (VRU). While planning the urban bypass, wider options of diverting pedestrians and slow-movingvehicles to local roads and minor corridors away from the planned urban bypass should be followed.

The following network strategies and measures can be helpful in reducing the exposure of pedestrians and slow-moving vehicles on an urban bypass;

- Restricting the number of intersections and direct access
- Provision of service roads
- Grade separation facilities for pedestrian and slow-moving vehicles at mid-block and intersections

6.3 Transition Zones

Transition zones are the locations where there is an interaction between urban bypass and various roads and in those areas, the design speeds are different. These transition zones should guide through physical changes of the roads which are obvious and explicit, but not to the extent that it may cause sudden braking.

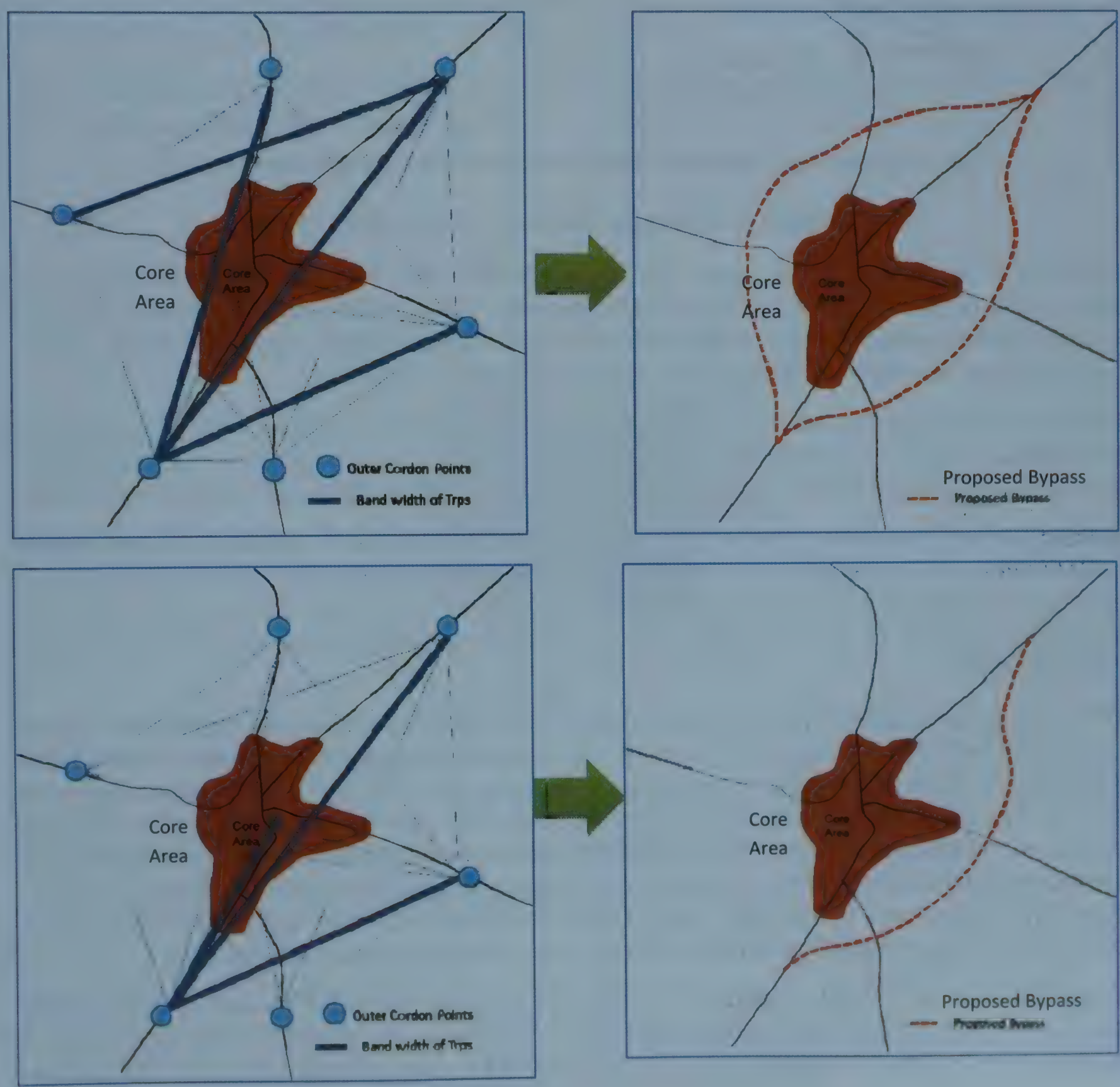
Speed limits should be recommended in these transition zones such as:

- Changes in horizontal and vertical alignment, cross-sections etc.
- Interchanges, roundabouts, intersections with gateway effect
- Changes between urban and rural settings
- Different streetscape, plantings or landscape, safety barrier etc.

The length of the transition zones may be based on deceleration rate of 0.8 m/s^2 and in general about 100 m to 200 m for each stepwise speed limit reduction of 20 kmph otherwise, the bypasses need not be subjected to speed limit restrictions so as to retain their functionality and mobility to the maximum extent.

6.4 Selection of Alignment

The bypass alignment should be identified based on Desire Line Diagram (DLD) using Origin-Destination (O-D) survey. The desire line diagram shows from which direction the major traffic plying through the city or interacting with the urban area in bandwidths. The alignment of bypass can be semi-circular or circular based on the travel movement pattern of the traffic in the city. **Fig. 4** illustrates some of the examples on selecting the alignment of urban bypass.



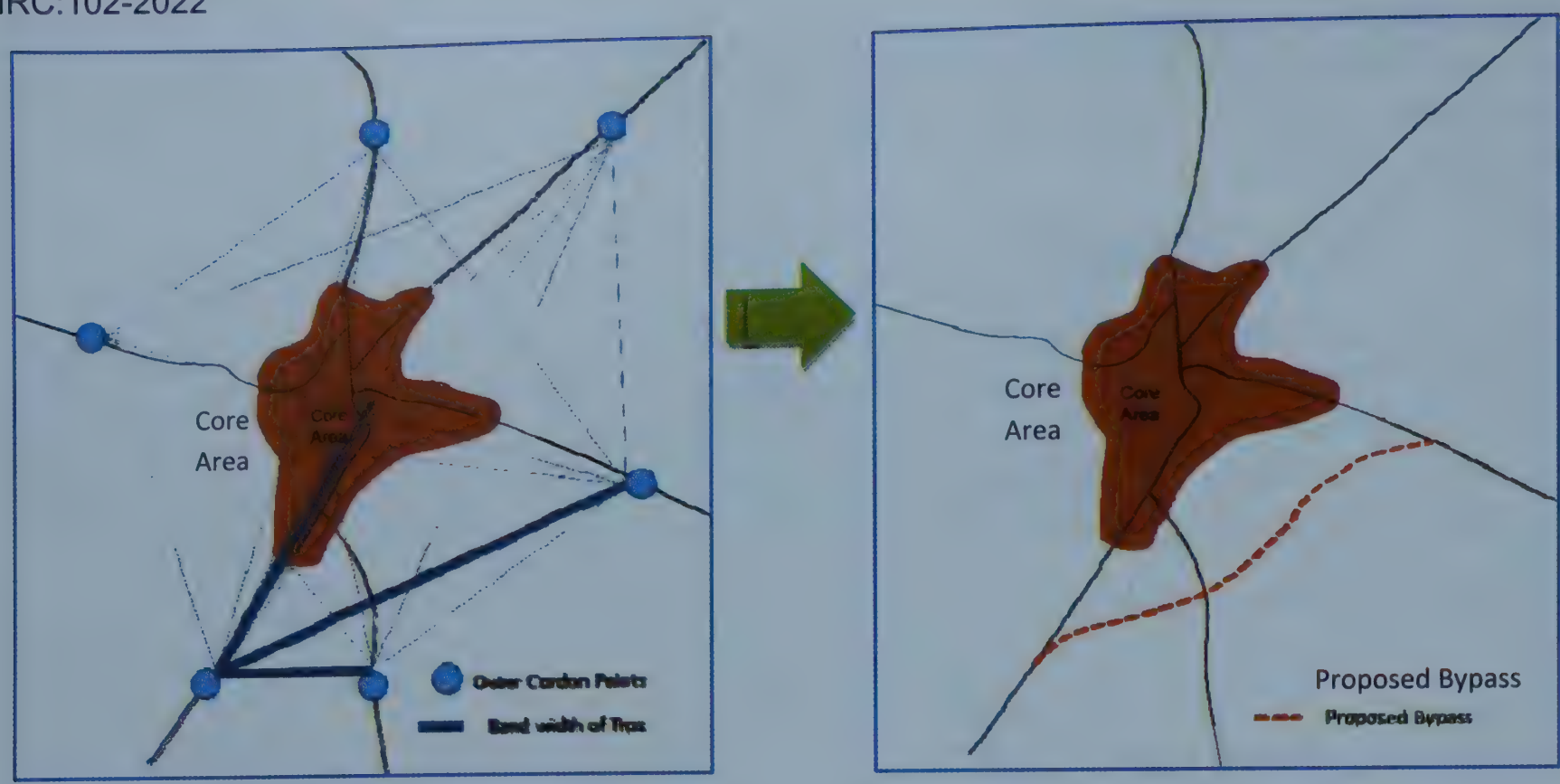


Fig. 4 Options of Bypass Alignment based on desire Line Diagram

7. URBAN BYPASS IMPACT ON LAND USE

Provision of an urban bypass eases the travel between the cities and it also increases the accessibility of the interchange locations of the bypass. The increased access results in increase in development in the interchange catchment area and along the intersecting roads where utilities such as water, sewage and other urban utilities services are provided.

Due to the urban bypass, land use will have direct and indirect impact. Direct impact is generally immediate changes such as conversion of barren or agriculture land to accommodate the bypass. It will also give access to the undeveloped land which should boost the real estate development.

Indirect impacts generally occur in the long term such as changes in development and growth patterns along the bypass road, as well as catchment area of interchange locations. Due to these changes, the liveability and local mobility may get affected. The planned urban bypass may shift the growth direction of the urban area with intense commercial, industrial and residential layout developments.

While planning the urban bypass, it is considered advisable to also evaluate the impact on land use, community character and local mobility. It is therefore, essential to undertake Social Impact Assessment (SIA) and Environmental Impact Assessment (EIA) for the proposed alignment options. The alignment passing through undeveloped land, may warrant more detailed analysis to understand the potential indirect impacts. The master plan or the land development authorities should restrict the development along the urban bypass and catchment of interchange locations. Any new development in the catchment of interchange locations and along the urban bypass road should have a Traffic Impact Assessment (TIA) study and site circulation plans.

Based on study of various bypasses in India, it is recommended that the urban bypass may be planned from 10 km to 40 km away from the core area of the city or the alignment may be planned by following the master plan growth boundaries in consultation with urban local bodies.

8. ORIGIN AND DESTINATION SURVEY

8.1 Selection of Survey Locations

Survey locations play a key role in obtaining the right data for these kinds of studies. To identify the survey locations, an imaginary urban agglomeration (cordon line) or master plan boundary needs to be overlay on the existing road network. Survey locations should be selected where the approach roads to the city intersect with the master plan boundary or imaginary line of urban agglomeration boundary under the study. **Fig. 5** shows a sample case for selection of survey locations.

The following points should be kept in view while locating the cordon:

- The imaginary cordon line should be well away from the town for effectively identifying the bypassable traffic; and
- The imaginary cordon line should encompass all existing bypasses catering to regional traffic moving around the town.

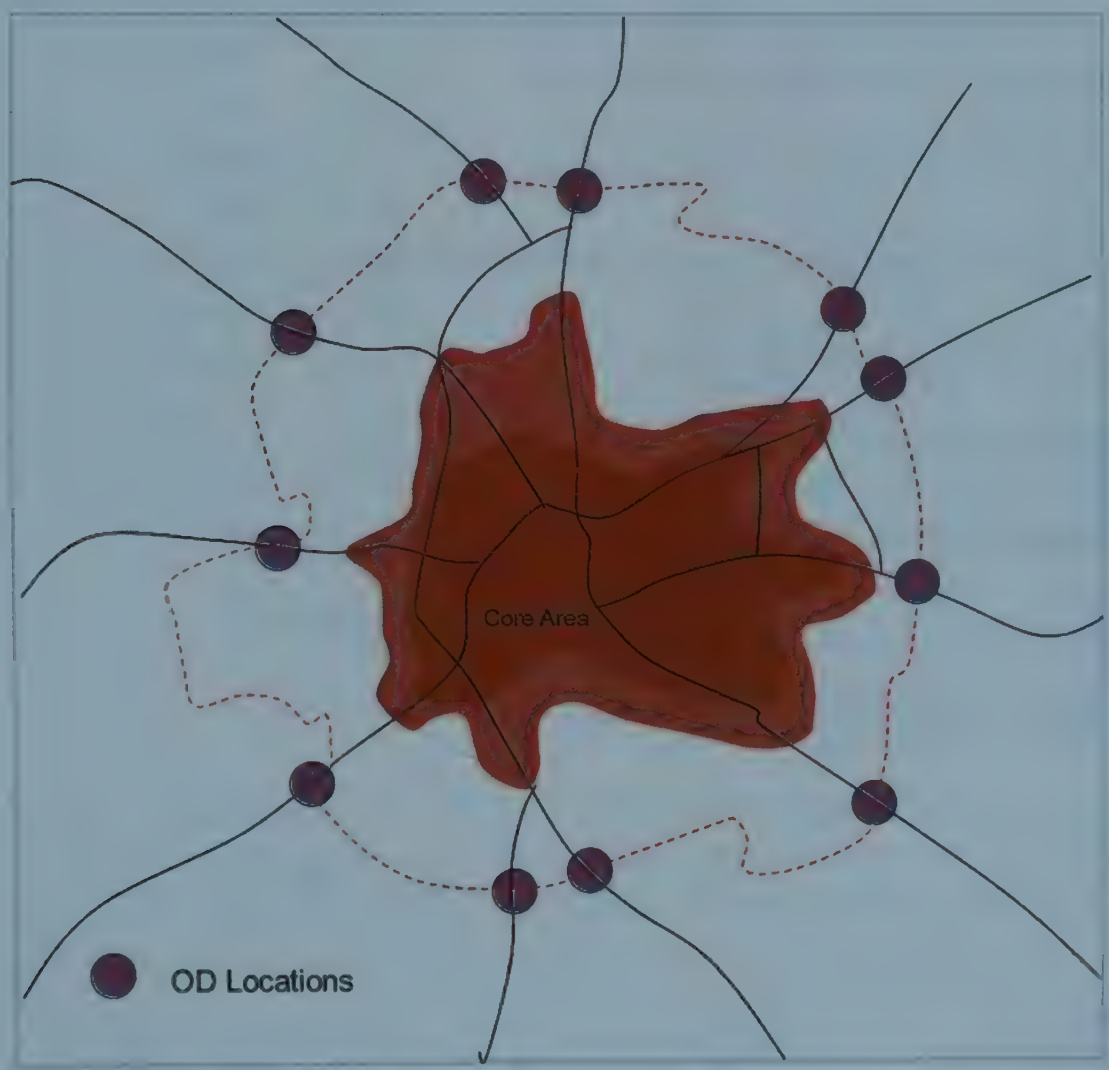


Fig. 5 Location of Cordon Line and Survey Stations for a Sample Case

8.2 Frequency and Duration of O-D Surveys

The surveys should be carried out simultaneously at all the selected locations, during the peak and the normal periods. The period in which these surveys are conducted should be so selected as to trap representative characteristics of the traffic (both goods and passengers). The surveys should normally be conducted for seven consecutive days but in any case for not less than three days and must encompass the weekly market day and one working day.

8.3 Sample Size

As far as possible, the survey should cover maximum percentage of traffic, and it is preferable to cover the entire traffic giving one hundred percent sample size. When this is not possible, the survey should cover a minimum percentage of traffic as given below:

- During peak periods : 20 percent of volume of traffic.
- During normal periods : 30 percent of volume of traffic.

In addition to this sample survey, classified traffic volume count should be conducted simultaneously during the survey period. This is basically required to expand the sample to the total population. Traffic volume count data by vehicle type should also be collected for every 15-minute interval by using **Form 1 (A & B)**. It is necessary to have video graphic surveys with adequate manpower deployment for monitoring.

8.4 Methodology

Depending upon the size of the urban area, and the level of accuracy required etc., the survey can be carried out by any of the following methods:

I. Registration Plate Matching Method;

II. Automatic Number Plate Recognition (ANPR);

III. Tag and Disc Method;

IV. Roadside Interview Method;

V. Fastag Method;

VI. Cell Phone and Global Positioning System (GPS)

8.4.1 *Registration Plate Matching Method*

In this technique, license plate registration number of the vehicle and time of entry and exit of the inbound and outbound vehicles are noted down by observers posted separately at each survey point. When survey is conducted on sampling basis for recording vehicles at entry and exit points, vehicles with registration numbers ending with pre-determined digits (say 1057 and excluding the letters) only are recorded. This method does not cause any inconvenience to traffic and is suitable for low to medium level traffic in urban areas. It is not possible to collect data regarding the purpose of trip, details of stopping through traffic, etc., by this method.

In the heavy traffic sections, it is not possible to collect 100 percent of data,so a sample-based survey will be carried out in that case. To reduce the duplication of traffic count,it is recommended that the vehicle registration number should match with more than 30 percent of recorded vehicle numbers. Every location recorded numbers will try to match with other locations and the estimated percentage will be removed from the overall traffic data to estimate the overall travel movement pattern of the study area.

3.4.2 *Automatic Number Plate Recognition (ANPR)*

In this technique, Automatic Number Plate Recognition (ANPR) cameras will be used similar to road pricing and other monitoring applications. The camera data consist of location data (road section, direction and field), date and exact passing time, and number plate. Use of ANPR technology reduces the need for on-site and video enumerators. Vehicle classification may also be observed and recorded for each license plate. The record of all license plates recorded from one roadside station is compared to records from other stations within the study area. A match is noted if a license plate is seen at two stations within a certain time parameter, that is upper and lower bounds of reasonable travel time between the two stations. This method can be used without any questionnaires. However, to gather any additional information about the trip, e.g. trip purpose, trip frequency and trip time a questionnaire must be accompanied. The **Fig. 6** below shows the sample process.

Location 1	Time
AP 21 DF 2340	14:14
TN 31 DC 1456	14:14
KA 21 AB 1342	14:15
KR 34 CD 4521	14:15
MH 22 SD 3451	14:15
MP32 KA 4566	14:15
DL 23 RA 7889	14:15
UP 23 RA 7889	14:15
UP 23 RA 7890	14:15
UP 23 RA 7891	14:15
UP 23 RA 7892	14:16
UP 23 RA 7893	14:16
UP 23 RA 7894	14:16
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Location 2	Time
-----	-----
-----	-----
-----	-----
-----	-----
-----	-----
DL 33 PA 4741	14:31
GJ 11 AA 3210	14:31
HP 31 CR 2421	14:31
CH 21 RR 3321	14:31
KR 34 CD 4521	14:32
MH 22 SD 3451	14:32
MP32 KA 4566	14:32
DL 23 RA 7889	14:32
UP 23 RA 7889	14:32
UP 23 RA 7890	14:32
UP 23 RA 7891	14:32
UP 23 RA 7892	14:32
-----	-----

Maximum Travel Time between Location 1 to Location 2 is 15mins

Fig. 6 Registration Number Plate Matching

Using ANPR video recording method, almost 100 percent of the data can be recorded with their registration plate. To reduce the duplication error in the recorded traffic volume of the study area, every location recorded vehicle registration numbers will try to match with other locations and the estimated match percentage will be removed from the overall traffic volume data to estimate the overall travel movement pattern of the study area.

3.4.3 *Tag and Disc Method*

The vehicles entering the town are stopped at survey points and tags with entries such as the time of entry, place of entry and type of vehicle are tied to the front of the vehicles by the surveyors posted to cover the inbound traffic. Sometimes instead of tags, discs are distributed to

the drivers. When the vehicles leave the town at the cordons, these tags or discs are collected by the surveyors posted at the survey points. Different coloured tags and discs can be distributed to identify the distributing station and type of vehicle with registration numbers ending with pre-determined digits (letters may be excluded) for easy identification.

8.4.4 *Roadside Interview Method*

Inbound and Outbound vehicles are stopped at the survey points and information on time of interview, type of vehicle, registration number of vehicle etc., are noted down by the observer. Thereafter, the observer puts questions in a polite manner to the driver or occupant to get information on origin, destination, purpose of trip, number and purpose of halts within the town, route followed inside the town, etc. **Form 2 (A & B)** may be used for collecting this information. Random sampling may be adopted to avoid any bias.

Along with the road side interview, it is recommended to conduct ANPR or vehicle registration number plate survey to avoid duplication of traffic volume in the study area. It is also recommended that the vehicle registration number should match with more than 30 percent of recorded vehicle numbers. Every location recorded numbers will try to match with other locations and the estimated percentage will be removed from the overall traffic data to estimate the overall travel movement pattern of the study area.

8.4.5 *Fastag Method*

In the recent times, the Central Government has initiated to have fastags in the regional traveling vehicles for ease of traffic movement at the toll plazas and revenue collection. In near future most of the regional travelling vehicles will have fastag installed. To get more accurate or 100 percent of origin-destination data, fastag information can be used. At each survey location the fastag readers will be installed to track the vehicle type and entry/exit time of the location. For each location, fastag reader will have a unique ID and based on the unique ID and recorded vehicle registration number by vehicle type will match with other survey location fastag readers to estimate the duplication percentage and estimated duplication percentage will be applied to the overall matrix to generate the origin-destination matrix. From the generated matrix, travel movement patterns will be estimated (I-E, E-I and E-E) and Desire Line Diagram (DLD), can also be plotted.

8.4.6 *Cell Phone and Global Positioning System (GPS)*

Receiver Cell phone tracking technology currently and presumably can only provide the data on phone (the owners) movements as cell phones transition from one cell tower to another cell tower. The phones must be on, even though not in use. The data from cell phone movements can possibly generate origin-destination data needed for support of planning models. However to date, this technology has not been used for an O-D study. Widespread utilization of GPS receivers for O-D data collection is currently cost prohibitive, especially for large rural and urban areas.

8.5 Requirements of Survey Stations

Adequate care should be taken to locate the survey station well away, from the carriageway to reduce interference to the passing traffic. If necessary, police help may be taken for conducting the survey. Adequate provision at survey point may be made to provide information to the road users regarding the purpose of the survey through installation of banners, etc.

9. TRAVEL TIME AND DELAY STUDIES

The travel time and delay studies can be conducted using three techniques.

a) Test Vehicle

b) Traffic Sampling Techniques or the License Plate Matching

c) ITS Probe Vehicle Techniques

9.1 Test Vehicle Method

Test Vehicle method can be conducted by the moving car technique. In this technique, a test vehicle is run at the perceptible average speed of the traffic stream. The observers inside the test vehicle note down the journey and delay timings and causes of delays. Depending upon the method of regulating the speed of the test car, the survey can be conducted by any one the following methods.

I. Floating car method

II. Average car method

III. Restricted car method

In the floating car method, the driver has to take an equal number of vehicles which overtake the test car. However, it is rather difficult to apply this method in our towns because of mixed traffic conditions. In the average car method, the driver runs the test vehicle at the speed which he considers as the average speed of the traffic stream. This method is restricted to conditions of continuous flow of traffic only and cannot be applied for free flow conditions.

The restricted car method is the same as average car method. But it overcomes the disadvantage existing in the latter by restricting the speed of test vehicle under free flow conditions to predetermined speed limits.

The following preliminary work must be carried out prior to conducting the survey

- The entire route should be divided into sections, each section having fairly homogeneous road and traffic characteristics along the entire length.
- The restricted speed of test vehicle under free flow conditions is determined by considering the existing speed limits; and
- If existing speed limits are not satisfactory, spot speed study should be conducted and restricted speed limits determined.

The test vehicle is run in both directions of test sections in order to cover all conditions of traffic. The cause, duration and location of stops and other delays are recorded. For recording the readings, a tape recorder can be advantageously used. **Form 3** may be used for carrying out this survey. In order to ensure accuracy of data, at least six, and preferably 12 runs per direction, must be made.

9.2 Traffic Sampling Technique

The second method i.e. Traffic Sampling Technique or the License Plate Matching collects travel time information by remotely monitoring the time taken by individual vehicles to travel across a

roadway segment. These techniques are similar to having someone standing next to a road and tracking the movement of individual vehicles. It can be carried out by following Methods:

I. Manual Method

II. Portable Computer

III. Video with Manual Transcription

IV. Video with Character Recognition

In the manual method, data is collected manually for the license plates via pen and paper or audio tape recorders and manually entering the number of license plates and arrival times into a computer.

In the Portable Computer, data is collected for the license plates in the field using portable computers that automatically provide an arrival time stamp;

In the Video with Manual Transcription, data is collected in the field using video cameras or camcorders and manually transcribing license plates using human observers;

In the Video with Character Recognition, data is collected on the field using video, and then automatically transcribing license plates and arrival times into a computer using computerized license plate character recognition

The following guidelines/points must be considered prior to conducting the survey:

- The positioning of observers or video recorders is paramount to the safe and effective collection of vehicle license plate characters.
- For video methods, a telephoto lens increases the number of good vantage points from which to record license plates.
- The positioning of observers on the near or far side of an intersection depends upon whether one wishes to include delay from the intersection in the preceding or following segment travel time.
- Sample sizes are typically not a large concern with the video or portable computer-based license matching techniques. However, minimum sample sizes should be verified with variability values from field data.

9.3 ITS Probe Vehicle Techniques

Another means of collecting Data is through use of ITS probe vehicle techniques. These systems typically have a high implementation cost and are suited for large-scale data collection efforts. However, they enable continuous data collection and for minimal human interaction. Five types of ITS Probe Vehicle Techniques can be:

I. Signpost Based Automatic Vehicle Location

II. Automatic Vehicle Identification

III. Ground Based Radio Navigation

IV. Cellular Geo Location

V. Global Positioning System

In signpost-based method of Automatic Vehicle Location (AVL), probe vehicles communicate with transmitters mounted on existing signpost structures. This technique has mostly been used by transit agencies.

In Automatic Vehicle Identification method, probe vehicles are equipped with electronic tags. These tags communicate with roadside transceivers to identify unique vehicles and collect travel times between transceivers.

In Ground Based Radio Navigation, method data are collected by communication between probe vehicles and a radio tower infrastructure. It is generally used for transit or commercial fleet management; this system is similar to the Global Positioning System (GPS).

In Cellular Geo-Location method, it can collect travel time data by discretely tracking cellular telephone call transmissions.

In Global Positioning System method, probe vehicles are equipped with GPS receivers and two-way communication to receive signals from earth-orbiting satellites. The positional information determined from the GPS signals is transmitted to a control centre to display real-time position of the probe vehicles. Travel time information can be determined from the collected data.

The ITS Probe technologies, generally require high capital and installation cost and low human effort, but require quite skill manpower.

The emerging ITS probe technique is of Data Collection using Google Distance Matrix API or Collecting Data from Google Traffic Layers which is shown on Google maps as well. Google maps has its own means to calculate average speed based upon distance (calculated based upon difference between latitude and longitude of two locations) and time taken by traveller to reach. It has been further updated by taking into consideration time posted by travellers using information and cellular geo location into account. The technique has been specified below. Google Maps provide with the traffic and travel time and delay information (**Fig. 7**).

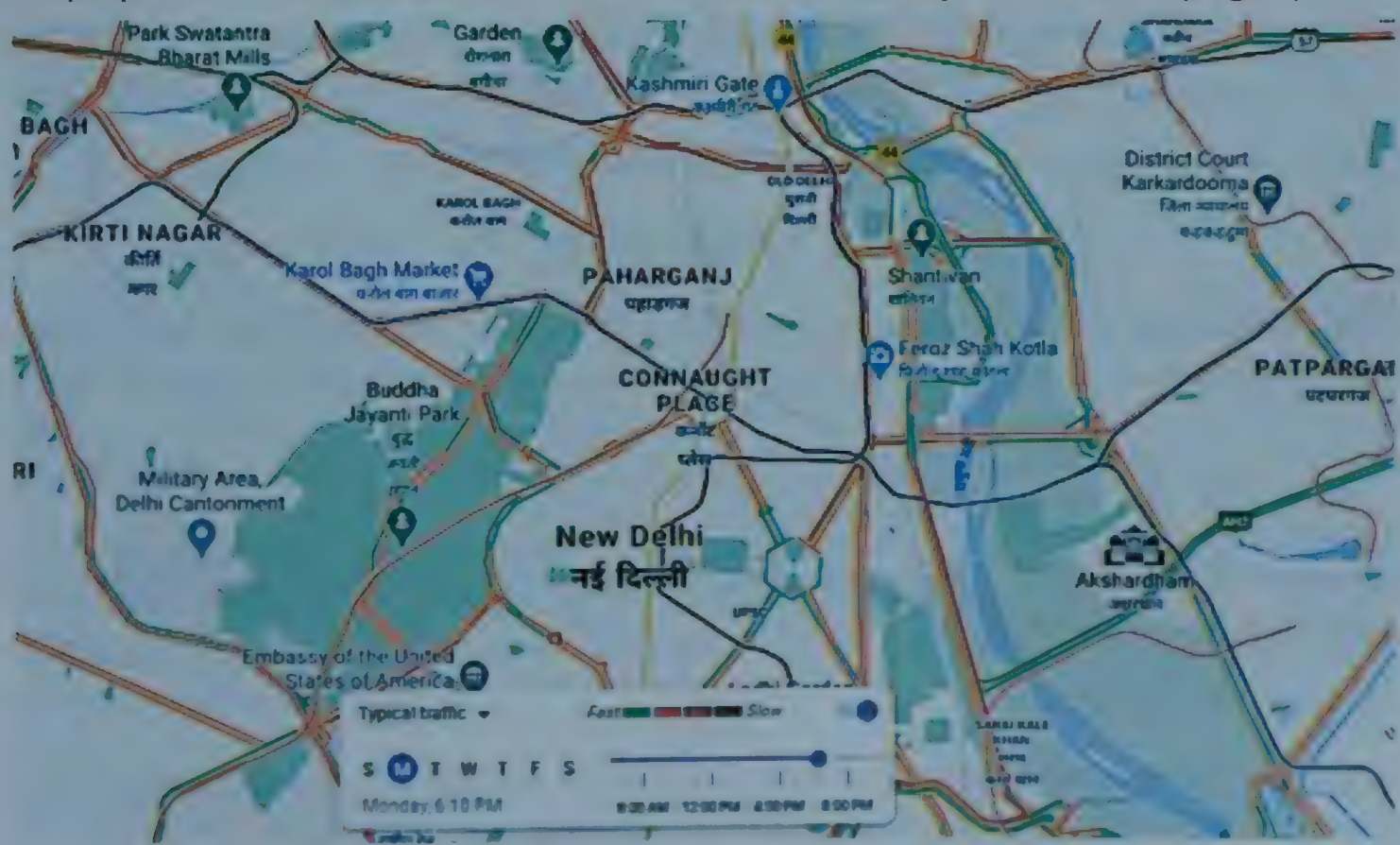


Fig. 7 Method to Estimate Average Speed by Google

Google Maps uses GPS to monitor the location of an object by "attaching" a GPS tracking device to it. At its simplest level, the tracking device is fitted with a GPS receiver and some way to record its current location (latitude and longitude coordinates) at regular intervals. Average speed is then calculated by dividing the total distance travelled by the elapsed time. GPS receivers generally perform the following tasks:

- Convert the difference between the two latitudinal/longitudinal positions into a unit of measurement.
- Determine the difference between the two time stamps to calculate how long it took to get from Point A to Point B.
- Calculate the average speed based on these results. For example, if the distance was three kilometres and the time taken was 5 minutes, then the average speed across that distance would be 36 kmph.

In this case, it doesn't take into account all of the factors that can impact travel time. Thus, the case of mobile phones and locations and time is considered through the GPS location of Phone.

GPS data from individual phones is used by Google Maps to estimate movement and speed of traffic in real time. This data informs Google's travel time estimates by reducing the average speeds in its calculations during periods of high traffic, or increasing the average speed when conditions are clear.

The method has an advantage of continuous data flow and real time analysis, any time anywhere. You can look at complete dataset and at many places at the same time.

Application of Google Traffic Data has been done for:

a) Bottle Neck Identification

b) Pre and Post Analysis [Before and After]

c) Queue Length Estimation

d) Flow Prediction with Machine Learning Principles

10. ANALYSIS

This section deals with processing and presenting the data collected from the surveys dealt with earlier, to evaluate the necessity for bypass, and to select a suitable location therefore, if-justified.

10.1 Analysis of Traffic Count

Hourly, volumes of traffic passing through various survey points are obtained by tabulating the traffic volume counts in **Form 4**.

10.2 Analysis of Delays

From the survey the average delays (which covers all delays including waiting time at level crossing) involved for each route are compiled by summing up the delays involved in each run and then working out the average delay, **Form 5**.

0.3 Speed-Flow Characteristics

rom the data already collected, speed-flow characteristics of the existing facility must be scertained. This would help in defining the level of service as obtaining at present.

0.4 Analysis of Origin and Destination Data

he data obtained from origin and destination survey should be tabulated in **Form 6** and the roportion of through traffic to total traffic obtained. The average delays during the 24-hour eriod as noted in **Form 5** should be grouped for different sections of the entire route in **Form 7**.

0.5 Analysis of Speed and Delay Characteristics

he travel speeds and traffic volumes as obtained from **Forms 3** and **4** respectively are used o develop a relationship between speed and volume for the route under study which may be of ne following kind:

$$V_{est} = V_f - KQ \qquad \textit{(Eq. 1)}$$

Vhere,

V_{est} = estimated speed,km/h

V_f = average free speed, km/h

K = a coefficient

Q = average hourly traffic volume, vehicles per hour

he travel speeds of local traffic in the absence of through traffic and of through traffic in the bsence of local traffic should be estimated from speed-volume relationship. The average travel me on different route sections should be found out based on observed and estimated speeds. he average delays should be taken as the difference between the average travel time with the bserved or estimated travel speed and the travel time with the average observed free speed. hese values should be tabulated using **Form 8** for the following cases:

I. Local traffic with through traffic;

II. Local traffic without through traffic;

III. Through traffic with local traffic; and

IV. Through traffic without local traffic.

he vehicle-wise break up of through traffic should be tabulated in **Form 9**.

he total loss in man hours and the total extra fuel consumed per day should be tabulated in **orm 10**, for-local traffic and through traffic separately for both the cases of their travelling ogether and separated from each other. The extra man hours and the extra fuel lost per day hould be calculated as follows:

(i) extra man hours or extra fuel lost per day for local traffic	Man-hours or fuel lost per day while travelling along with through traffic (observed) ***minus*** man hours or fuel lost per day while travelling without through traffic (estimated).
(ii) extra man hours or extra fuel lost per day for through traffic	Man-hours or fuel lost per day while travelling along with local traffic (observed) ***minus*** man hours or fuel lost per day while travelling without local traffic (estimated).

The direct economic losses in the base year which include the extra man hours and extra fuel should be quantified by adopting suitable monetary values for local and through traffic in **Form 11**.

10.6 Travel Demand Projection

The necessity of a bypass can be better emphasized by working out the details for a future date since present demand may vastly increase due to:

(i) Growth of the region; and

(ii) Attraction of more traffic by new facility due to improved level of service offered

A twenty-year period is normally assumed to be the design period for a road project. However this can be suitably altered to suit the local conditions.

The traffic counts pertaining to the town during previous years, if available, can be used for projecting the growth of traffic to the design year. If no such data is available, the traffic can be projected by the growth factor method, on considerations of the growth of region with respect to population, fuel consumption, number of registered motor vehicles etc. Changes in level of service for each year will then have to be determined keeping in view the projected yearly growth in traffic.

The Elasticity Method relates traffic growth to changes in the related economic parameters. This method studies, in an appropriate perspective, the changes in observed past traffic volumes in the context of changes in relevant economic indicators in the Social Impact Assessment (SIA) to which it was closely related in the past. Such parameters include Net State Domestic Product (NSDP), income accruing to the major sectors of the economy, etc. This method takes into account not only the past growth of the major economic indicators, but also the future perspective. According to IRC-108, elasticity based econometric model for highway projects could be derived in the following form (Eq. 2)

$$Log_e P = A_0 + A_1 \, Log_e (EI) \qquad \text{(Eq. 2)}$$

Where,

P = Traffic Volume;

EI = Economic Indicator;

A_0 = Regression constant;

A_1 = Regression co-efficient (Elasticity Index)

Based on the projected elasticity values for study area roads and the growth of SIA, the future average annual compound traffic growth rates by vehicle type have been estimated by using the following relationship (Eq. 3)

$$TGR = (NSDPgr) \times E \qquad (Eq. 3)$$

Where,

TGR = Traffic growth rate for mode

NSDPgr = Growth rate of NSDP in Public Influence Area (PIA)

E = Elasticity value for mode

From the projected traffic, the vehicle-hours lost, man hours lost etc., and the anticipated economic loss for the design year could be obtained using **Form 12**.

The design speed, which depends on the characteristics of traffic in the region, can be obtained after comparing the speeds of traffic on similar bypasses in the region. With this data, the geometric details of the bypass and the cost of the projects to meet the needs of the projected traffic can be worked out.

10.7 Economic Analysis

The economic savings due to the provision of the facility is compared with the anticipated economic loss had the existing facility been continued up to the design year for the purpose of determining the justification for the construction of the bypass. While carrying out this economic analysis, savings due to likely reduction in number and severity of accidents brought about by the provision of a bypass and improvement in level of service offered by the existing facility due to a reduction in traffic volume levels (through traffic having been assigned to the bypass) should also be considered.

11. PRESENTATION

The through traffic analysed according to origin and destination in terms of passenger car units (Rural) and projected to design year is represented by means of desire line diagram, treating the survey points as origins and destinations. Such a diagram will clearly indicate the control points and the most suitable alignment for the bypass.

12. STANDARD DRAWINGS

12.1 Cross Sections

Typical cross sections for various types of urban roads includes urban expressway, Arterial, Sub arterial and collector streets are given in IRC:86 (Geometric Design Standards for Urban Roads and Streets). These cross sections are appropriately to be selected based on the Right of Way (ROW).

12.2 Intersections

Ministry of Road Transport and Highway provided details of intersection at by-pass take off involving National Highway and Urban roads. These drawings will be useful as standard drawings for intersections. Drawings 1 to 5 provided standard drawings for intersections at bypass take off points with different take off angles (30°, 45° and 60°).

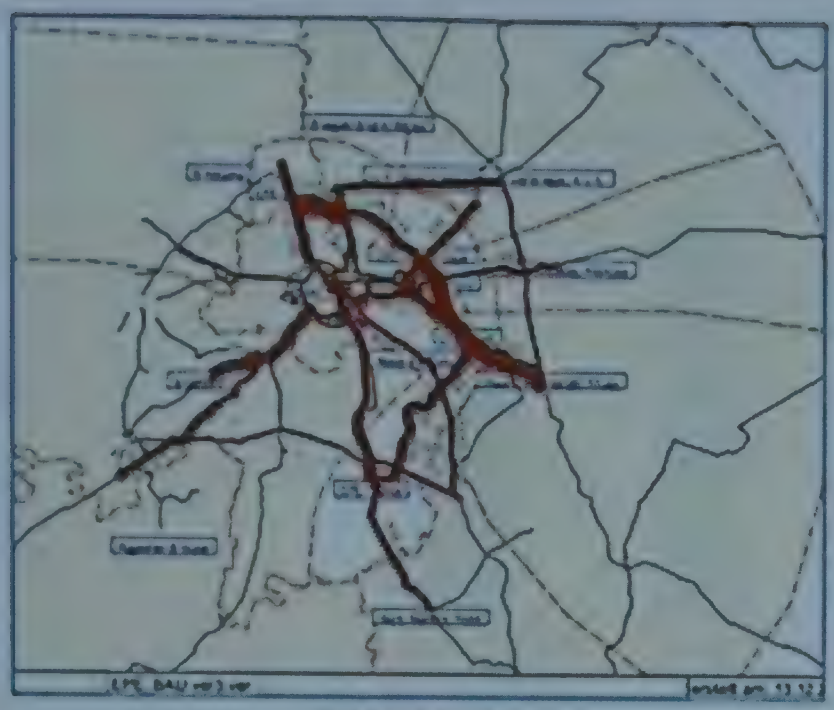
13. LEARNINGS FROM NATIONAL EXAMPLES - CASE STUDIES

13.1 Eastern Peripheral Expressway

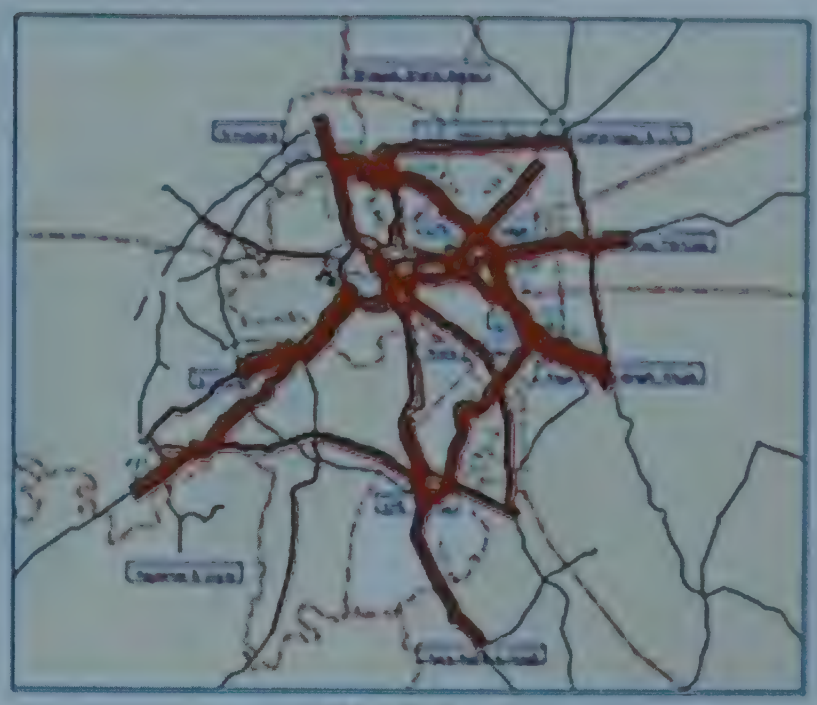
Eastern Peripheral Expressway (EPE) also called Kundli-Ghaziabad-Palwal (KGP) Expressway or National Expressway (NE) II. The Length of the expressway: 135 km. It is six lane Divided carriageway and Passing through the states of Haryana and Uttar Pradesh. One of the major concerns in Delhi is the hazardous level of air pollution. Vehicular pollution is being a major source of this pollution, various policies and strategies have been applied to decongest and de-pollution in Delhi region. With the same objective, EPE was constructed to reduce vehicular congestion and pollution by diverting vehicles passing from Delhi through EPE. The alignment of EPE is shown in **Fig. 8**.

Fig. 8 Eastern Peripheral Expressway

CSIR-CRRI conducted study to Quantify of the reduction of air pollution level due to bypassing vehicular traffic on Eastern Peripheral Expressway (EPE) (CRRI, 2019) the study findings described below.

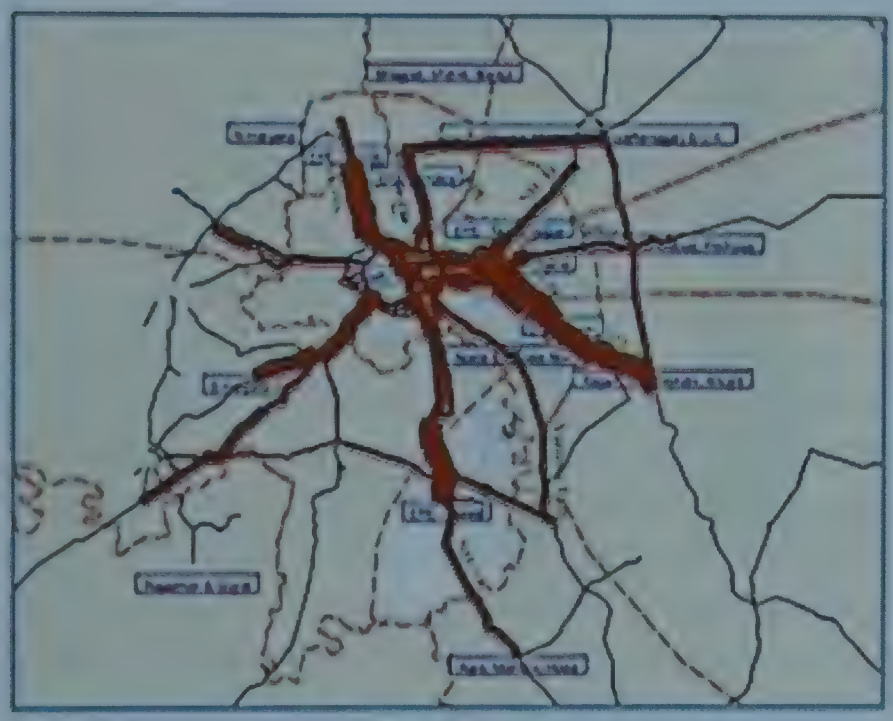


Weekend

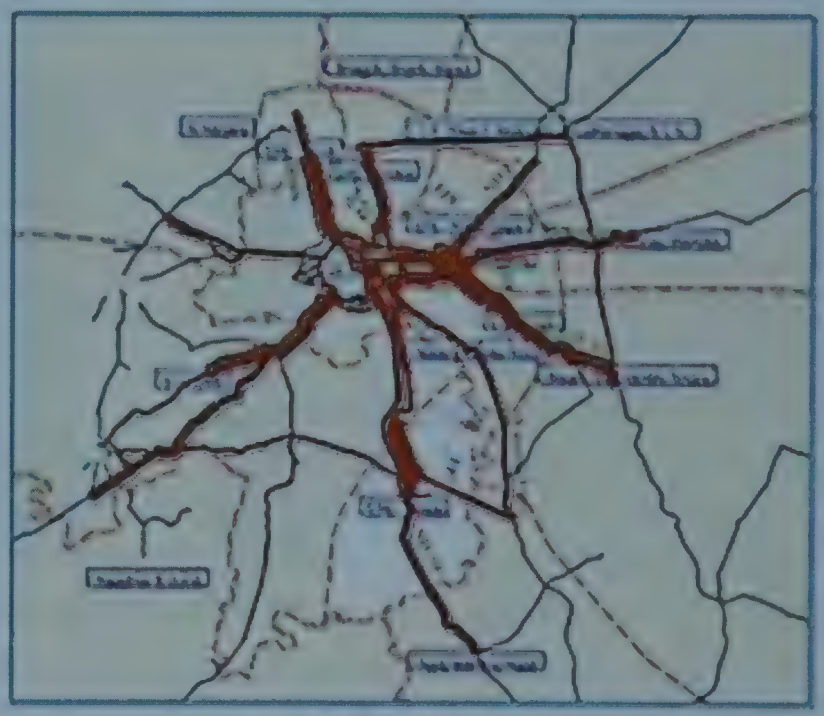


Weekday

a) Scenario1: When EPE is Existing (Business as Usual)



Weekend



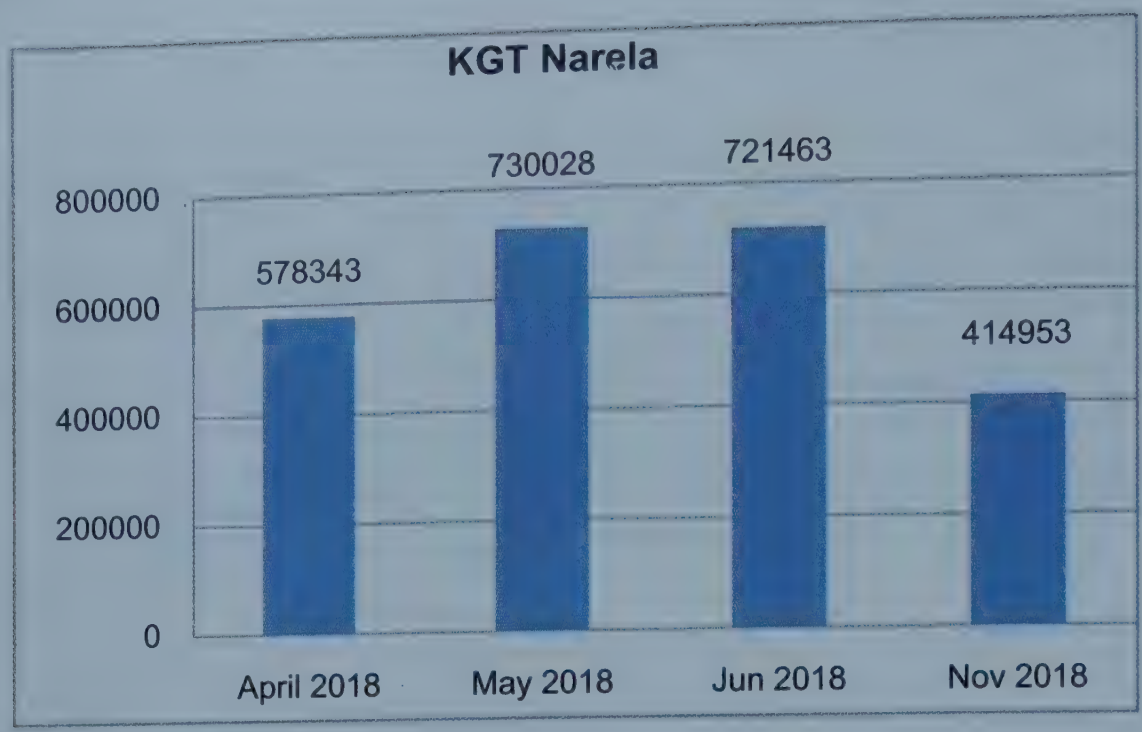
Weekday

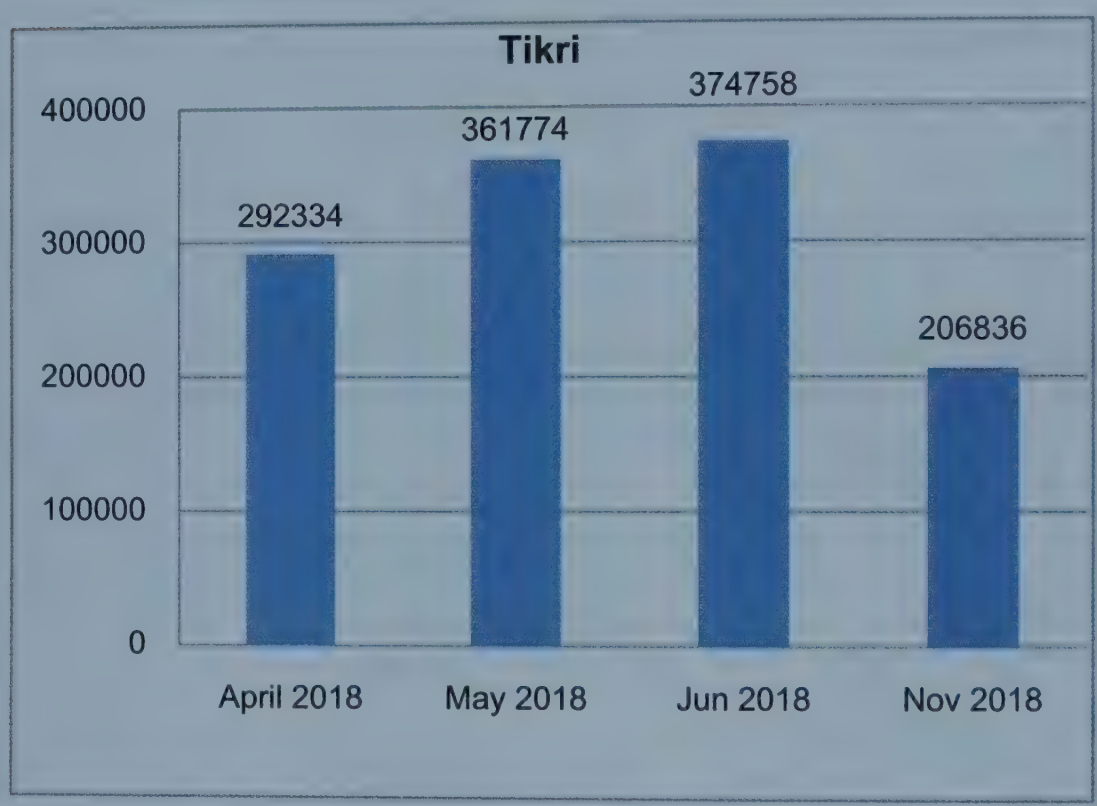
b) Scenario 2: when EPE is not Existing

Fig. 9 Travel Demand Analysis: Figure presents the Traffic Assignment Results When (a) EPE is existing and (b) EPE is not existing

13.2 Variation in Traffic Volume at Delhi Border due to EPE Operation

A comparative evaluation of traffic data before and after EPE operation has carried out by CSIR-CRRI for three locations including Singhu Border, Badarpur Border and Bahadurgarh. **Fig. 10** shows the comparison of the traffic volume (Monthly wise data considered from South MCD) at Delhi border due to EPE operations. It was observed from the figures that the reduction of traffic was observed 13% and 11% at KGT Narela and Tikri border respectively. Whereas traffic volume increase of 6% at Badarpur border (CSIR-CRRI).





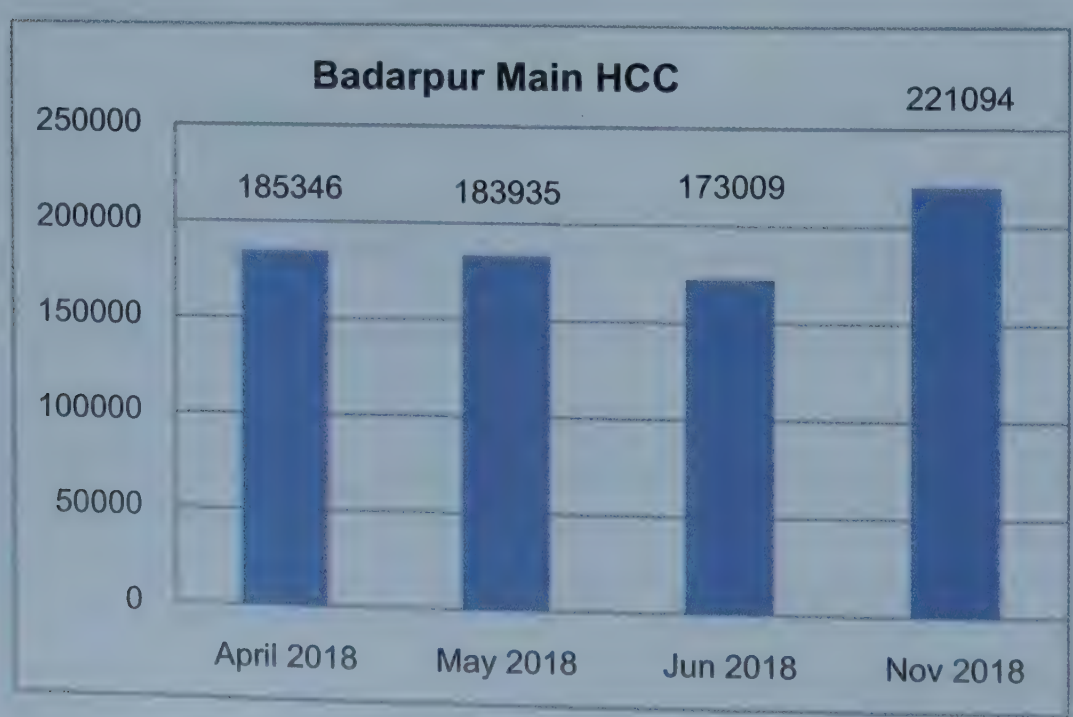


Fig. 10 Variation of Traffic Volume due to EPE Operation at Delhi Border (CSIR-CRRI)

Travel Time Analysis: Journey time of vehicles using EPE is represented in Blue Colour and journey time of vehicles using other than EPE roads represented in red colour (**Fig. 11**). It is observed that the average journey time for the trip from Kundli to Palwal using EPE is 119 minutes and if the trip was made through city, the journey time is about 161 minutes. The average saving of journey time is about 43 minutes.

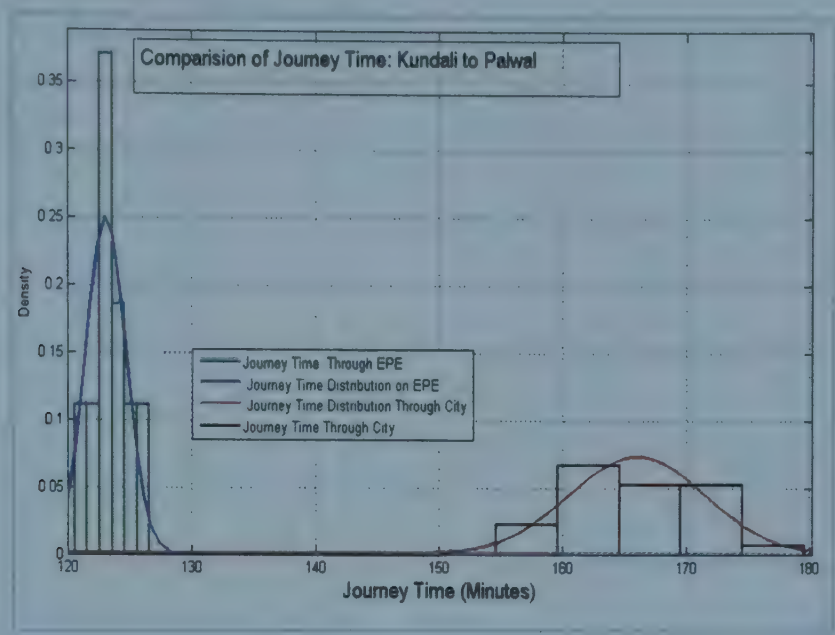


Fig. 11 Travel Time Distribution of Traffic using through City and EPE

13.3 Outer Ring Road Hyderabad

The Hyderabad Outer Ring Road (ORR) is a road-cum-area development project, as it aims at the development of well-planned and well-connected urban settlements around the Hyderabad Metropolitan Area (HMA). The 162 km ring road links the peri-urban areas Patancheru – Shamshabad – Hayathnagar – Medchal - Patancheru, providing connectivity to various State Highways and National Highways so as to by-pass the central city of Hyderabad. Further, to augment the traffic circulation, 33 radial roads were proposed to be developed that connect the city to the ORR (Road Traffic Technology 2013). The Hyderabad ORR would provide linkage/ connectivity to newly established Hyderabad International Airport located at Shamshabad, which is 35 km away from the city. **Fig.12** shows a sketch of the alignment as depicted on the Draft Development Plan of HMA. While HMA is governed by the Hyderabad Metropolitan Development Authority (HMDA), the central city of Hyderabad is governed by the Greater Hyderabad Municipal Corporation (GHMC).

Fig. 12 Alignment of Outer Ring Road Hyderabad

FORM 1A: Classified Traffic Volume Count – Passenger Vehicle

NAME OF ORGANISATION OR AGENCY													
PROJECT TITLE													
Location:				Near by land mark				Date:			Shift:	Day / Night	
Direction:	From		To		Lane configuration of road			Enumerator:			Sheet no:		
	Passenger Vehicles									Non-Motorized			
Time* (15 min Interval)	2 Wheeler	Auto	Cars/ Vans/ Jeep (Private)	Cars/ Vans/ Jeeps (Taxi)	Shared Vehicle (Tata Magic)	Buses (State Roadways)	Buses (Private)	Mini Buses	Ambulance/ Police, Army Bus	Cycle	Cycle Rickshaw	Animal Hand Drawn	Hand Drawn Cart
.00 - .15													
.15 - .30													
.30 - .45													
.45 - .00													
TOTAL													
Conducted by :													

*based on the case area the vehicle typology may vary

FORM 1B: Classified Traffic Volume Count – Freight Vehicle

NAME OF ORGANISATION OR AGENCY												
PROJECT TITLE												
Location:					Near by land mark			Date:		Shift: Day / Night		
Direction: From		To			Lane configuration of road			Enumerator:		Sheet no:		
Passenger Vehicles									Non-Motorized			
Time*	2-Axle Trucks	3- Axle trucks (10tyres)	MAV's		LCV's							
			(4-6 Axles) / HCM/EME	7 or more Axles	Type 1 (4 Tyre)	Type 2 (6 Tyre)	Type 3(Mini LCV)(Tata Ace,Pickup Van)	Goods Auto	Agriculture Tractor	Agriculture Tractor-Trailer	Army Trucks	Others
.00 - .15												
.15 - .30												
.30 - .45												
.45 - .00												
TOTAL												
Conducted by :	Company Name											

**based on the case area the vehicle typology may vary*

FORM 2A: Outer Cordon – Origin Destination Survey - Passenger Vehicle

NAME OF ORGANISATION OR AGENCY											
PROJECT TITLE											
Road Name											
Land Mark											
Weather: Fine/Cloudy/Rainy											
Direction	From		To								
1	2		3		4	5	6	7	8		
Sl. No.	**Mode Type**		**Origin**		**Destination**	**Trip Length**	**Trip Time**	**Trip Frequency**	**Purpose of Trip**		
	1	2 Wheeler	Area		Area			1. Daily	1		Work
	2	Car						2. Alternate Days	2		Business
	3	Taxi						3. Twice in a week	3		Education
	4	Auto						4. Weekly Once	4		Social
	5	Shared Auto	Land Mark		Land Mark			5. Monthly Once	5		Shopping
	6	Cycle						6. Occasionally	6		Home
	7	Cycle Rickshaw							7		Others
	1	2 Wheeler	Area		Area			1. Daily	1		Work
	2	Car						2. Alternate Days	2		Business
	3	Taxi						3. Twice in a week	3		Education
	4	Auto						4. Weekly Once	4		Social
	5	Shared Auto	Land Mark		Land Mark			5. Monthly Once	5		Shopping
	6	Cycle						6. Occasionally	6		Home
	7	Cycle Rickshaw							7		Others
	1	2 Wheeler	Area		Area			1. Daily	1		Work
	2	Car						2. Alternate Days	2		Business
	3	Taxi						3. Twice in a week	3		Education
	4	Auto						4. Weekly Once	4		Social
	5	Shared Auto	Land Mark		Land Mark			5. Monthly Once	5		Shopping
	6	Cycle						6. Occasionally	6		Home
	7	Cycle Rickshaw							7		Others
	6	Cycle						6. Occasionally	6		Home
	7	Cycle Rickshaw							7		Others
Conducted by : Company Name											

FORM 2B: Outer Cordon – Origin Destination Survey - Freight Vehicle

NAME OF ORGANISATION OR AGENCY										
PROJECT TITLE										
Road Name										
Land Mark										
Weather: Fine/Cloudy/Rainy										
Direction	From			To						
1	2		3		4		5	6	7	8	9
Sl. No.	**Mode Type**		**Origin**		**Destination**		**Trip**	**Trip**	**Trip Frequency**	**Commodity**	**Tonnage**
	1	Mini LCV	Area		Area				1. Daily		
	2	LCV							2. Alternate Days		
	3	Two Axle							3. Twice in a week		
	4	Three Axle							4. Weekly Once		
	5	MAV	Land Mark		Land Mark				5. Monthly Once		
	6								6. Occasionally		
	7										
	1	Mini LCV	Area		Area				1. Daily		
	2	LCV							2. Alternate Days		
	3	Two Axle							3. Twice in a week		
	4	Three Axle							4. Weekly Once		
	5	MAV	Land Mark		Land Mark				5. Monthly Once		
	6								6. Occasionally		
	7										
	1	Mini LCV	Area		Area				1. Daily		
	2	LCV							2. Alternate Days		
	3	Two Axle							3. Twice in a week		
	4	Three Axle							4. Weekly Once		
	5	MAV	Land Mark		Land Mark				5. Monthly Once		
	6	Cycle							6. Occasionally		
	7	Cycle Rickshaw									
Conducted by : Company Name											

FORM 3: Speed & Delay Survey (Floating Car Method)

NAME OF ORGANISATION OR AGENCY											
PROJECT TITLE											
DATE & DAY											
NAME OF SURVEYOR:											
ROAD FROM						ROAD TO:					
ROUND NO				ROUTE NO							
LINK		Mileage meter reading			Journey Time (Min)						
FROM NODE	TO NODE	START	END	NET DISTANCE (KM)	START	END	NET TIME (min.)	TIME (Sec.)	LOCATION	CAUSE of Delay	
CAUSE OF DELAY		1 TRAFFIC SIGNAL		3 CONSTRUCTION/ REPAIR WORKS				5 OTHERS			
		2 CONJECTION		4 RALLY / VIP PASSING							
CONDUCTED BY : COMPANY NAME											

FORM 4: Hourly Summary of Classified Traffic Volume Count

NAME OF ORGANISATION OR AGENCY																	
PROJECT TITLE																	
Location:						Date:								Shift: Day/Night			
Direction: From				To		Enumerator:								Sheet no:			
	Passenger Vehicles							Goods Vehicles					Non-Motorized				Total NMT
Time*	2-W	Cars	Auto	Shared Auto	Bus	Mini Bus	Trucks (2A and 3A)	MAV	LCV	Goods Auto	Tractor	Total Motorized	Cycle	Cycle Rickshaw	Animal hand drawn	Hand drawn cart	
6 - 7																	
7 - 8																	
8 - 9																	
9 - 10																	
10 - 11																	
11 - 12																	
12 - 13																	
13 - 14																	
14 - 15																	
15 - 16																	
16 - 17																	
17 - 18																	
18 - 19																	
19 - 20																	
20 - 21																	
21 - 22																	
22 - 23																	
23 - 24																	
24 - 1																	
1 - 2																	
2 - 3																	
3 - 4																	
4 - 5																	
5 - 6 Hours																	
TOTAL																	
Conducted by : Company Name																	

FORM 5: Speed and Delay Analysis

NAME OF ORGANISATION OR AGENCY								
PROJECT TITLE								
Location:				Nearby land mark				Date:
Direction: From		To		Lane configuration of road				Enumerator:
Period of Journey (Hours)	Duration of Delays (in Minutes) in the Route							
	Run 1	Run 2	Run 3	Run 4	Run 5	Run 6	Total	Average
6 – 7								
7 - 8								
8 - 9								
9 - 10								
10 - 11								
11 - 12								
12 - 13								
13 - 14								
14 - 15								
15 - 16								
16 - 17								
17 - 18								
18 - 19								
19 - 20								
20 - 21								
21 - 22								
22 - 23								
23 - 24								
24 - 1								
1 - 2								
2 - 3								
3 – 4								
4 – 5								
5 – 6								
TOTAL								
CONDUCTED BY : COMPANY NAME								

FORM 6: Origin and Destination Survey-Percentage of Bypassable Traffic

NAME OF ORGANISATION OR AGENCY							
PROJECT TITLE							
Location:				Near by land mark			Date:
Direction: From		To		Lane configuration of Road			Enumerator:
Survey Station	Total Number of Vehicles				Total	Percentage of Bypassable Traffic to Total Traffic	
	Fast Moving Vehicles	All Vehicles	Through Fast Moving Vehicles	Destination Fast Moving Vehicles		Excluding Slow Moving Vehicles	All Vehicles
TOTAL							
Conducted by : Company Name							

FORM 7: Speed and Delay - Summary of Analysis of Delays on the Entire Route

NAME OF ORGANISATION OR AGENCY				
PROJECT TITLE				
Location:				Date:
Direction: From		To		Enumerator:
SL. NO.	Route Section	Length (Km)	Period of Journey (Hours)	Average Delay (Minutes)
			8.00 - 12.00	
			12.00 - 16.00	
			16.00 - 20.00	
			20.00 - 8.00	
			8.00 - 12.00	
			12.00 - 16.00	
			16.00 - 20.00	
			20.00 - 8.00	
			8.00 - 12.00	
			12.00 - 16.00	
			16.00 - 20.00	
			20.00 - 8.00	
TOTAL				
Conducted by : Company Name				

FORM 8: Analysis of Observed and Estimated Travel Speeds and Delays

NAME OF ORGANISATION OR AGENCY							
PROJECT TITLE							
Location:				Date:			
Direction: From		To		Enumerator:			
Route Section	Length (Kms)	Average Hourly Traffic Volume (Veh/hr)	Average Travel Time (Mins)	Average Travel Speed (Kmph)	Average Free Speed (Kmph)	Average Travel Time With Free Speed (Mins)	Average Delay (Mins)
TOTAL							
Conducted by : Company Name							

FORM 9: Origin and Destination Survey-Route Wise Analysis of Through Traffic

NAME OF ORGANISATION OR AGENCY					
PROJECT TITLE					
Location:				Date:	
Direction: From		To		Enumerator:	
Period (Between hours)	Number of Vehicles				Total
	Trucks, Truck-Trailers	Buses	Cars, Jeeps, vans, Three Wheelers	Motor Cycles and Scooters	
8.00 - 12.00					
12.00 - 16.00					
16.00 - 20.00					
20.00 - 8.00					
TOTAL					
Conducted by : Company Name					

FORM 10: Origin and Destination Survey Analysis of Economic Losses to Local and Through Traffic

NAME OF ORGANISATION OR AGENCY													
PROJECT TITLE													
Name of Town			Losses in Manhours and Fuel				Route No:						
Vehicle Type	Vehicles per Day	Loss in Manhours per day			Extra fuel consumed on acceleration and deceleration process				Extra Fuel Consumed in Idling		Present Rate of Consumption	Extra Wear and Tear in terms of Fuel consumed in litres per day	Total extra fuel Consumedin litres per day
		Average Delay per vehicle (Mins)	Average Occupancy per Vehicle	Manhours lost per day (in hour)	Mean number of process	Extra fuel consumed per process in litres	Extra fuel consumed per day per process in litres	Mean stopped time in minutes	Extra Fuel Consumed per minute of Idling	Extra Fuel Consumed per day in Litres			
CAUSE OF DELAY		1 TRAFFIC SIGNAL	3 CONSTRUCTION/ REPAIR WORKS					5 OTHERS					
		2 CONJECTION	4 RALLY / VIP PASSING										
Conducted by : Company Name													

FORM 11: Assessment of Direct Economic Losses for Local and Through Traffic (Base Year)

NAME OF ORGANISATION OR AGENCY							
PROJECT TITLE							
Vehicle Type	Man Hours lost per day	Man hours Lost per Year	Total Cost of man hours lost per year in rupees	Total Extra Fuel onsumed in Liters	Cost of Fuel per litre in Rupees	Total Cost of Extra Fuel Consumed per Year in Rs.	Total Economic Losses per Year in Rupees
TOTAL							
Conducted by : Company Name							

FORM 12: Projected Economic losses for through and Local Traffic

NAME OF ORGANISATION OR AGENCY					
PROJECT TITLE					
Year	Through Traffic in Vehicles Per Day	Direct Economic Losses for Through Traffic in Lakh Rupees	Local Traffic in Vehicles Per Day	Direct Economic Losses for Local Traffic in Lakh Rupees	Total Direct Economic Losses for Local and Through Traffic in Lakh Rupees
BASE YEAR					
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					
16					
17					
18					
19					
20					
TOTAL					
Conducted by : Company Name					

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